

## *Collective work characteristics in business information system development*

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**ABSTRACT** *System information development methodologies have developed greatly in recent years. However, although most of them take into account user's involvement and participation in several development process phases, none of them have explicitly considered the issue of cooperative work in the design of business information systems, or its use. A model using Ergonomics techniques, cognitive mental models and classical engineering is presented. This model is applied during the development of a corporate workflow system in a Brazilian technological research company. The application was done through action research Methodology. It has allowed us to demonstrate the need of discovering the most important and common points in the users' activities and the construction of the collective image of the system. Finally, the model limitations are discussed as well as the the research design continuity.*

**Keywords** *Collective analysis at work; Ergonomics; Software Prototyping; Mental Models; Software Development.*

## 1. INTRODUCTION

In the traditional software development approach (Business Information Systems), the most frequently used hypothesis is that models are centered on a single user. This user is seen as standard and independent to the environment or group in which he/she is placed. This single user model is generalized in order to study the collective behavior of the system by involving all its users.

Therefore, the important features of collective work are not considered explicitly in this approach.

To bridge this gap, a model using a wide range of techniques was introduced, such as classical engineering, ergonomic concepts, software prototyping and cognition mental models formation, in order to deal with collective and cooperative work issues to be considered in the computerized design system. Action research is used as the research methodology to apply the collective analyses of the work method.

This paper aims to allow us to address the following questions:

- What are the instruments to be prepared in order to capture the collective dimension and understanding of an activity which is going to be computerized?
- How to use these instruments for mapping out the collective work aspects for an information system?

It is accepted in this work that the conventional business software development methods do not adequately cover the collective dimension and understanding of the work in the use of information systems, both in its conception and in its correction and/or improvement (SOMMERVILLE, 2007).

The model is applied to a corporative workflow project within a large technological research institute in Brazil, demonstrating how to consider the collective issues of work in a software development project and the results that were obtained from the model application.

This work is organized as follows: firstly, the main concepts of the presented model are defined, and then these concepts are logically linked to one another. The application is accompanied by action research methodology based on the presented theory and finally, results are discussed and recommendations are made for the continuity of this work.

## 2. MAIN CONCEPTS

### 2.1. Collective work

When dealing with the work issue, the term cooperation can be defined in a broader way in the sense that two or more people cooperate when they work hard on a joint task towards a certain goal. For this goal to be achieved actions from both are necessary; therefore, cooperating is operating in common, seeking an adjustment by new communication, reciprocity or in complementary operations (PIAGET, 1996).

The definition used in this work is given by Dejours (2005, p. 93):

Cooperation is a coordinated procedure, defined as an action of participation in a common work. Cooperation supposes a place where, at the same time, singular contributions converge and the dependence relationships crystallize among the individuals.

Therefore, the cooperation notion refers to collective work.

## 2.2. Collective analysis at work

The collective analysis at work (CAW) is a work analysis method in which employees (users, in the case of informatics) describe their own activities in work situations to the other employees and to external observers relative to the work relationship (stakeholders, also in the case of informatics) (FERREIRA, 1993).

The CAW central point is the choice of a theme (demand), which corresponds to the work situation activity which has to be explored by the employees performing it. The demand represents a commitment on the part of employees for achieving results.

### 2.2.1. The CAW techniques

The CAW techniques may vary significantly, and there may be one or several successive sessions (FERREIRA, 1993).

For the specific groups, after a general and brief presentation of each participant, a person is chosen to explain the activity in further detail. Later on, each employee will have the chance to speak providing more details. Two important points are emphasized:

- Researchers must make an initial explanation of the purpose of their work. New subjects may be developed within the group but this must be a reason for new negotiations.
- The researchers have to understand the activity details and try to perform them in different ways, even if that takes time. One cannot simply pretend to have understood. Details must be clearly understood. A good technique corresponds to describing the activity chronologically.

### 2.2.2. General considerations on CAW and results

In this work, some results and general considerations on CAW should be pointed out:

- The learning process is inverted. Employees are the ones who know and researchers are the ones who do not. Everyone has something special and unique to relate: their real activity. According to the author, this inversion valorizes the employee and provides a highly positive atmosphere.
- To explain what one does, one must previously reflect on what is done, which is not a normal process, being explicit and raising awareness on everything that used to be done automatically. For one who is expressing, to express is to be made aware: he/she does not only express for the others, but expresses that he/she knows his/her own goal. One does not usually think about the activity performed, but about its results; the activity itself is what matters and it has to be explained.
- The process facilitates the discovery of common points in the employees' activity.
- It allows analyzing the work under different situations: work content, production requirements, relationships with colleagues and higher management, work environment, etc.
- The CAW result not only has objectivity, but also subjectivity (employees value what they describe: what is good, bad, what they like, or what is dangerous).
- The material resulting from CAW can be used in different ways by different specialization areas.

## 2.3. Mental model and interaction

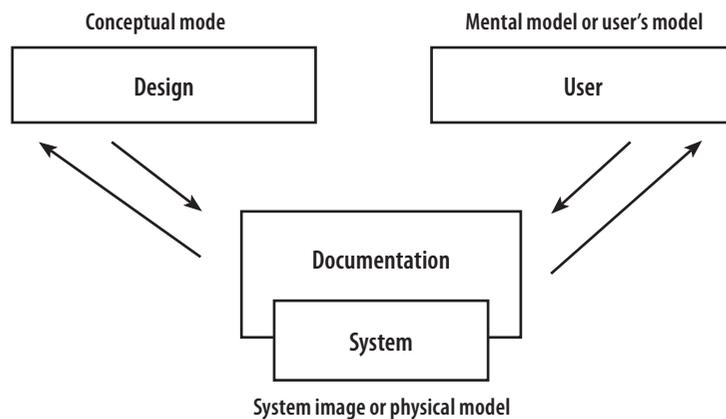
This model (figure 1) corresponds to knowledge representations of how the system operates, its components and its relations, the internal processes and how these affect the components (NORMAN, 2002):

- The conceptual model is created by the designer from users' requirements; their capacities; knowledge and experiences and is useful for designing the system and for teaching how to use it.
- Mental model, or users' model, may be defined as the result of users' actions based on their experience and deriving from other actions in other systems and tasks. It is the model that the user keeps in mind and obtains results from the way the image of the system is interpreted.
- System image or the physical model is the concrete structure that was built which is not always related to the mental model.

The conceptual model is a means to create the mental model and should allow the user to interpret what is happening through the system interface and documentation (system image).

A greater facility for learning and using depends on correct mapping between the mental and the conceptual model (NORMAN, 2002). The mental model is not formed from the conceptual model directly, since the latter results from the way the user interprets the system image.

Figure 1 – Mental models



Source: NORMAN (2002)

In this way, the designer's task is to build an adequate image of the system, understanding that all the elements which the user interacts with helps to form this image, for example: physical buttons; keyboards; video monitors; documentation (instruction manuals, helps, etc.); error messages; data input and output help facilities and all the elements of man-computer interface.

## 2.4. The Ergonomics of interfaces and usability

As seen earlier, the user's mental image is assembled through the system image and one of the main elements of this image corresponds to the user interface. By means of the interface the usability is perceived by the user, and that subjective satisfaction will be attained. For users, the interface practically builds the system.

Interface is the result of the man-computer interaction and is composed by two elements (HIX & HARTSON, 1993):

- The interaction development. Communication with the user is developed in terms of operator actions and of the functioning of the interface, considering the principles of ergonomics; guidance manuals; users' cognitive limitations; graphic design; interaction styles and usability specifications. The purpose is to ensure usability, functionality, performance and users' satisfaction.
- The software development provides this interaction. At this point, interaction will be implemented by means of algorithms, programming languages, data structures, and other information technology techniques. It is important to point out that most of the programming effort lies in the development of this interaction, in which this number may reach 80% of the total effort expended (SILVA, 1997).

In interface interaction component development, several styles can be used. These styles may be defined as a collection of objects and techniques available to the interface designers for the interaction development, including the appearance and the behavior of those interaction objects (SCAPIN, 1986).

## 2.5. Storyboarding and prototyping techniques

“Storyboarding” basically corresponds to any technique expressing the system behavior, project or implementation intention under the user's perspective. They may be categorized in three types (LEFFINGWELL & WIDRIG, 2003):

- Passive: this is composed by pictures, screen shots, sketches, etc. In this case, the rules of the system in its sequence are presented to the user, with an explanation.
- Active: this corresponds to a sequence of figures which show an automated description of the way the system behaves during typical use or in an operational scenario; for example, in an automatic slide presentation.
- Interactive: this allows the users to interact with the system more realistically, requiring their participation. It may be a simulation of the possible scenarios (non-functional prototype), or even a simplified functional prototype of the system.

The functional prototyping implements parts of the system requirements by the construction of a prototype which executes the real behavior of this system (with the implementation of algorithms and database), and may use tools especially built for making this type of prototype (BOAR, 1984).

In turn, the non-functional prototyping takes in the users', stakeholders' and the system behavior by interactions and iterations with them, through a set of graphic interfaces simulating the real behavior of the system (without the implementation of algorithms and database).

## 3. MODEL PRESENTED

According to subsections 2.2, 2.3, 2.4 and 2.5, the non-functional interface prototyping will be used, so that it is possible to induce the users' mental model from the image system created by the designers.

For this, the process described in 3.1 is used, for which an initial prototype is developed, used as the initial interaction model of the system (figure 2 (b)).

This model must be successfully refined together with the users, using the cognition concepts (mental models) discussed in 2.3, starting from the initial model and receiving new components (figure 2 (c)).

The use of the prototype will serve as a basis for applying the Collective Analysis at Work method, previously described in 2.2.

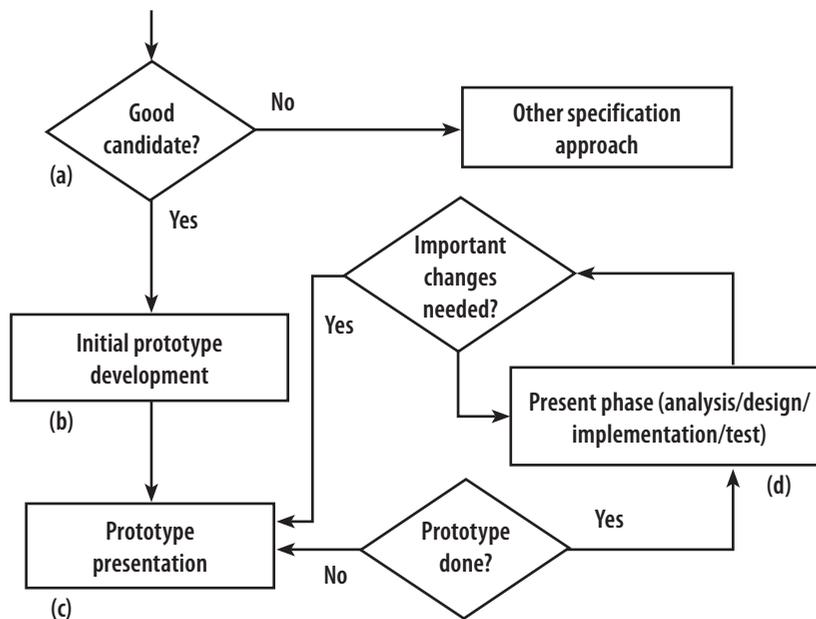
After successive interactions, sub-phase (d), figure 2, is reached. At this point, there is a functional prototype of the system (the system has already been developed in its fundamental aspects).

### 3.1. Process for executing the model presented

The purpose of the process described in this subsection is that of contextualizing the application of the model presented within a software development methodology, defining its application process.

For steps (a), (b) and (c) of figure 2, a description is made, an output criterion and the artifacts produced.

Figure 2 – Process for applying the model presented



Source: Authors

#### 3.1.1. Good Candidate for the Process Proposed (a)

As defined previously, prototyping may be applied to a set of systems which should have the following characteristics (BOAR, 1984):

- The system does not require a great amount of algorithmic specification, in which the application must be a structured problem with a large number of data elements and relationships among records but having a small number of algorithmic processes.
- Users must be willing and capable of participating actively, as must the project manager.
- The system has a lot of interaction with the users by transactions with reports associated to the database, not operating with much processing batch.

This work deals with collective information systems which are not under a simple organization center (without a clear distinction between communication and coordination), but distributed in the users' behavior pattern (CROWSTON & KAMMERER, 1998; WEICK & ROBERTS, 1993). For other computer supported cooperative work applications (CSCW), where a clear distinction exists between coordination and communication, the model 3C (Collaboration, Coordination and Communication) can be used (ELLIS *et al.*, 1991).

The output for the next step occurs when the consideration of all the factors is sufficient to decide whether the process presented is the most adequate for the problem in question.

### 3.1.2. Development of Initial prototype (b)

The initial prototype should have enough details so as to provoke discussion and iteration (next phases).

At this point, it is more important to present the functionalities elicited in the previous phase in a less sophisticated manner than detailing storyboards, reports and data (which must be detailed along the iteration process of the prototype with users).

Issues on the performance, access, safety, etc. have to be postponed for later phases. Only the user's view should be considered, taking into account the main artifacts surveyed in the previous phase, allowing the next phase to start with a model which will serve as an excellent "anchor" for the process.

The main output artifacts are: list of events, flowcharts, use cases (LEFFINGWELL & WIDRIG, 2003), storyboards and preliminary data model.

The output for the next step occurs when there is enough content to allow a significant discussion on the next phase.

### 3.1.3. Prototype Presentation (c)

The purpose of this step is to get new and revised requirements by the observations and criticism made by the users on the prototype.

In the initial iterations, by the method described in 2.2, the focus must be on the detection of gross deviations of the use cases (flowcharts or any tool used to guide sessions) (BOAR, 1984).

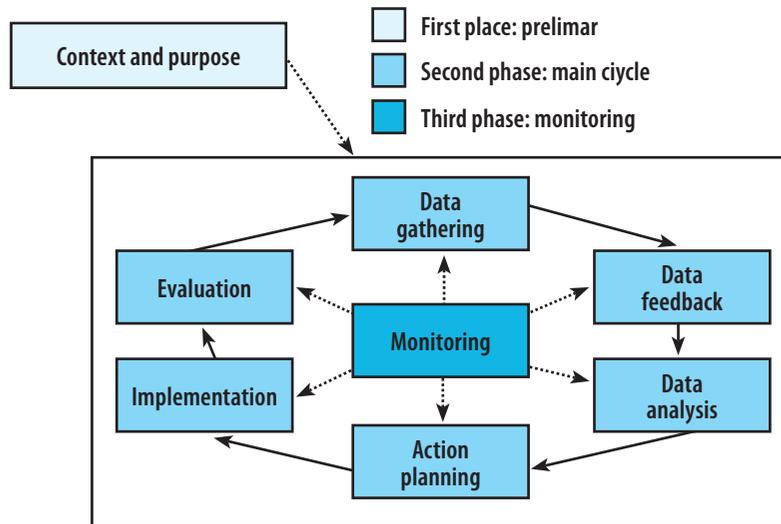
Later, the refining phase is started, with greater concern about the interface and new functionalities are discovered. The output artifacts are: event list, use cases and/or flowcharts, storyboards/ detailed interface models and preliminary data model.

In the end, the model has to be revised and consensually approved by all participants (if that is the case, from the company chairman to the user who will operate it), since several perspectives have to be considered.

## 4. METHODOLOGICAL STRATEGY: ACTION RESEARCH

Action research corresponds to a sort of social research with an empirical base conceived and conducted in close association with an action or with a collective problem resolution, and in which the researchers, representatives of the situation or problem, are involved in a cooperative or participative way (THIOLENT, 2004).

Figure 3 – Action research cycle.



Source: COUGHLAN and COUGHLAN (2002); MIGUEL (2005)

Figure 3 shows the three phases of the action research (COUGHLAN & COUGHLAN, 2002). The first phase (preliminary phase) corresponds to understanding the context in which the research will be conducted, as well as the purpose of the work conducted. This phase also involves the establishment in the necessary justifications for the action required, besides the justifications for the research.

The second phase (six-step conduction - main cycle) starts with data gathering (diagnosis and/or data collection when the research is under way), feedback (for those involved in the research), analysis of this data (with those involved in the research), action planning (definition of the intervention to be made), action implementation (putting what was planned into action) and evaluation (verifying whether the implementation results attained the expected effects), going back to new data gathering (if necessary), closing the cycle (first iteration).

These cycles are constant and sequential, and are continuous as long as necessary, and there may be a more comprehensive cycle (for the research as a whole) and smaller cycles for specific parts of the work.

The third phase comprehends a verification of each of the six previous steps, so as to verify what knowledge was generated in the conduction of the action research, so that the researcher has to be interested not only in the project operation but also in the monitoring of the learning process, which will lead to the theoretical contribution of this type of empirical development (MIGUEL, 2005).

The complete action research plan consists of the following items:

- Context and purposes: This step shows why the action research methodology was chosen and the definition of a project for its application.
- Cycle 1: In this cycle, the initial prototype of the system (figure 2(b)) is executed, together with the application of the steps to conduct this cycle.
- Cycle 2: the non-functional prototype (figure 2(c)) is executed, with the application of the steps for conducting this cycle, by using the model presented in which CAW sessions were applied.
- Cycle 3: the functional prototype of the system is developed.

This work approaches the context and purpose step, besides the first and second cycles. The third cycle is currently being executed and will not be considered in this work.

## 5. RESEARCH RESULTS

### 5.1. First phase: context and purposes

The model was applied in a large Brazilian company which develops technology with about 1,500 collaborators.

Several types of services are rendered to clients, from specialized technological services (tailor-made for a given problem), up to routine services.

At present, this company consisting of 50 laboratories which offer a broad type of services, and, in spite of the existence of a series of internal norms about general aspects which should be established for the services in general (order, budget, etc.), each one of these laboratories applies these norms in a different way according to the requirements of their clients, as centralization of these services does not exist.

As a consequence of lack of standardization, the work is released independently by each laboratory (in many of them, the service process is made through paper files); information is fragmented and difficult to put together. Feedback to the clients is slow and imprecise.

This service process corresponds to a workflow, with several stages, from starting the order up to its conclusion, so as to involve the collective work of the laboratory participants (technicians and secretaries), especially in those laboratories offering several types of services, each one complementing the other (the same client order may contain several service requirements from one or more laboratories).

Frequently clients request a specific set of services which involves the joint participation of several laboratories, each one contributing with its own specialized service (in this case, laboratories should work collectively in order to obtain the final set of services).

Faced with this present problem, the company staff approved the development of an information system, with the following objectives:

“The technical follow-up service system has as its objective to, normalize the follow-up methods and administration of technical laboratory services in the whole company, giving standardization and greater efficiency to the development and follow-up of technical services, from the moment of the request of a service, up to its fiscal document emission.

This system allows for the creation of budgets, registering samples, obtaining a number of technical documents and generates invoice requests, all totally integrated with other company information systems.

It is also possible to carry out the daily follow-up activity of the laboratories through a set of reports, as well as supplying managerial information about the main activities performed”.

The action research methodology was chosen, as the model presented employs an ergonomics technique (Collective Analysis at Work - subsection 2.2) which uses action research for its application, requiring the researcher, as a group member, to understand how and why his/her actions can change or improve the laboratory's work under the collective work view.

### 5.2. Presentation of Cycle 1

The purpose of this cycle is to define the initial prototype of the system.

#### 5.2.1. Data gathering

The viability analysis of the project in question was conducted when the latter was proposed to the company. This evaluation was developed and presented in the form of a project proposal containing a general diagram of the project, time for implementing the first phase estimated at 12 months (cycles 1 and 2), estimated costs and technicians involved in the work. This document was used as a basis for the initial step.

This study also generally defined the scope of the system, the vision of the document and the general characteristics of the system.

### 5.2.2. Feedback and data analysis

Once the project was approved outlining the general scope, the project team was put together, composed of two laboratory representatives, a business analyst and a systems analyst, the data feedback phase was initiated, through sessions with the committee who defined this project (members of the company commercial area).

As the document which initiated the proposal, presented the project in general terms only (concerning both the main requirements and the interfaces with the other systems) and also due to the project complexity, the decision was to conduct an analysis of the laboratory service process [16].

The main intention of this analysis corresponded to mapping out the users main activities (in this case, that of the technicians and secretaries), through normal communication which occurs among the participants within the service process.

### 5.2.3. Planning the action

The technique defined by Estorilio (2003) was applied in two laboratories for obtaining the flowchart and interfaces definition.

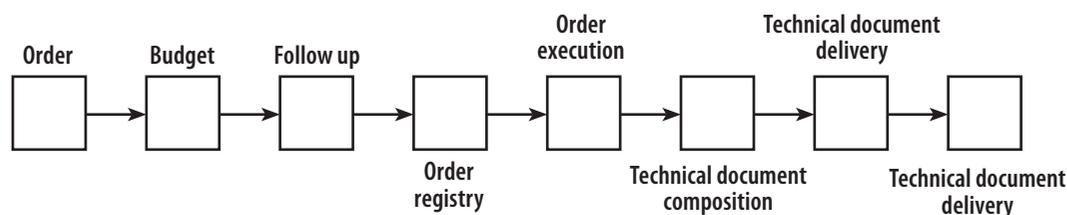
The option was for the use of the flowchart as a guide to the collective analysis at work and not for the IDEF0 (Integration Definition for Function Modeling), as this representation is preferable, due to its simplicity and detailing format, presenting the workflow in a single model, by interlinking effective tasks, whereas the IDEF0 presents the process in a generic way and it is modeled in several separate documents (ESTORILIO, 2003).

### 5.2.4. Implementation and evaluation

In the implementation stage; the main interfaces of the initial prototype were defined, as well as the general flowchart for the process. For each of the phases defined in the process flowchart, one or more interfaces, the input and output data was established, the necessary actions (by means of specific icons), as well as the navigability among the different interfaces, directed by the flowchart were also established.

In figure 4, the initial flowchart can be seen, showing the normal sequence for the service workflow.

Figure 4 – Simplified flowchart of the service workflow at the end of cycle 1.



Source: Authors

The non-functional prototype interface for the process “Order” is shown in figure 5. Icons can be observed for defining the actions with the subsequent process (“Budget” process and “Send process” icon), as well as the option to research new clients in the database system.

Figure 5 – Non-functional prototype interface (process “Order”) at the end of cycle 1.

ORDER			
			Close application
<b>Responsible:</b>	John Smith	<b>Date:</b>	01/17/2008
		<b>Request number:</b>	100
Request description:	Combustion - Determination of carbon and sulfur		
<b>Client:</b>			Research new client
Company name:	ACME	Company local registry:	99.9999.94/0001-99
Contact:	Mary Stuart	Phone:	1234 5678
E-mail:	mstuart@acm.com	Fax:	1234 1234
Next process:	Budget	Send to:	Peter Stevens
			Send process

Source: Authors

The assessment at the end of this cycle was made by the project team and company business division members. Also, a diagram of events was obtained along with the main high level use cases (LEFFINGWELL & WIDRIG, 2003).

### 5.3. Presentation of Cycle 2

This cycle corresponds to refining the initial interaction model of the system, until it is ready to proceed to the project/ implementation phase (figure 2 (d)).

The main purpose of this cycle lies in defining the non-functional prototype of the system, according to the model presented (see subsection 3.1).

This cycle will be conducted through sessions employing the Collective Analysis at Work with representatives from the different laboratories (six cycles on the whole). These sessions were developed and conducted by at least two people, one in charge of documenting and the other in charge of conducting the session.

The main characteristics of each session are:

- An initial explanation by researchers should be given with respect to the objective of the work and research.
- Using the lead question: "What do you do".
- The sessions were recorded (with the participants' permission).
- In general, a single meeting was accomplished with each laboratory group, with a basic set of items used as a guide (these sets of items were improving always that the cycle was being conducted).
- Researchers should understand details about the activity and try to perform them in several ways.
- To use facilitator role: His/her responsibility consists of protecting all of the group members against attacks and ensuring that all have the same opportunity for participation.
- Also evaluate subjectivity (how the workers rate: what is good, what is bad and what they like).
- Making decisions based on consensus of opinions.

The results obtained at the end of the cycle 1 are input to the step of implementing of the cycle 2.

### 5.3.1. Evaluation and data collection

Corresponds to the phase in which the model described in section 3 is applied. In the case in question, the starting point was the initial prototype defined in 5.2, consisting of the flowchart and the non-functional prototype of interfaces presented to the participants in the CAW sessions.

### 5.3.2. Feedback and data analysis

The feedback, in this case, was initially performed together with the other participants of the session (documenters and facilitator) aiming to normalize the points discussed during data collection.

The user feedback is conducted through the evaluation of the same reports generated during the evaluation and data collection phase.

Therefore, in this phase, the transcription of the data recorded is performed, occasional figures drawn along the session are reviewed and other documents are generated, depending on the methods chosen for implementing the system (for example: use case diagrams, class diagrams, event diagrams, data model, etc.) (GAVA *et al.*, 2004).

### 5.3.3. Action planning and implementation

The changes in the documents which will be presented in the next CAW session are defined, both relative to the system model collectively seen by the users and in respect to the session strategy; for example, focus on certain issues not yet clarified, or still pending system functionalities, etc.

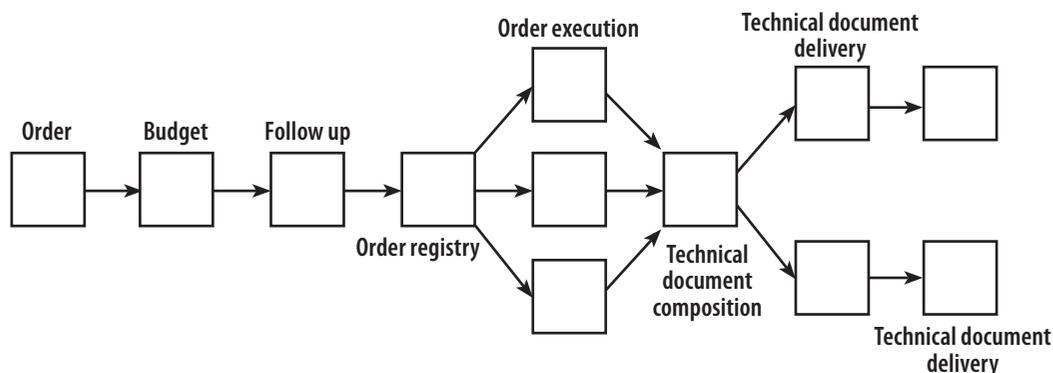
The changes are implemented in the form of new characteristics in the system image, by means of the due alterations in the artifacts (interface screens, flowchart, use cases, etc.) and documentation presented.

### 5.3.4. Evaluation and data collection

A new cycle is started and, in the case of this action research, with new users from other laboratories, and using characteristics of the service process (service workflow) different to the previous cycles.

Figure 6 shows flowchart and figure 7 shows the non-functional prototype interface for the process “Order” - both at the end of the sixth interaction cycle.

Figure 6 – Flowchart for the service workflow at the end of cycle 2.



Source: Authors

Figure 7 – Non-functional prototype interface (process “Order”) at the end of cycle 2.

Main page		WORK GROUP: Laboratory of chemical analyses		Close application	
<b>ORDER</b>					
Request number: 100		Responsible: John Smith		Date: 01/17/2008	
Brief request description:		Combustion - Determination of carbon and sulfur			
<b>CLIENT</b>					
1st Company name:		Company registry 1:			
2nd Company name : ACME CO		Company registry 2: 99999994000199			
Contact:		Mary Stuart		Phone 1: 1234 5678 Extension:	
E-mail :		mstuart@acm.com		Phone 2: 5678 1234 Extension:	
Contact way:		By Phone		Fax: 1234 1234	
Print label					
Next process:		Budget		Send to: Peter Stevens	
End request		Send process			

Source: Authors

## 6. CONCLUSIONS

The model presented was applied in cycles 1 and 2 of the action research, according to section 5. Consequently it was possible to obtain a non-functional prototype which was close to the collective image of the system (according to subsections 2.2 and 2.3). This model enables users to visualize how they fit in, how others will act, and how their actions will affect the others. It embodies their ideas about the goals of the group and how these may be accomplished.

In conclusion, the following results are presented, associated to this collective work:

- The joint construction with the users of the collective image of the system (both by the flowcharts and by the interfaces and documents distributed in the sessions) allowed them to give an overall vision of the whole comprehensiveness of the service process (figures 4 and 6).
- The CAW sessions facilitated the discovery of the common points within the employees' activities.
- The use of Collective Analysis at Work provided a greater integration between the employee/user, allowing the participants to better understand their activities, improving the level of suggestions for implementing the computerized system, as well as in certain cases the improvement of the current process.
- The method presented is concerned with what is done (functionality) and also with how it is done (interaction, figures 5 and 7), obtaining from the beginning of the project, a rapid solution convergence. Also some characteristics of collective work were obtained early in the information system development, for instance, usability characteristics related to the interrelations of the users actions (specific prototyping reports showing the progress of the services execution, the users position within the workflow process, as well as their introduction of data, etc.).

This research presents a first attempt for a better mapping out of the collective characteristics of an activity specific to the business information system which are contained in it (either partially or fully).

With the system in real use (cycle 3 of the action research – currently on-going and not discussed in this paper), the development of cycles 1 and 2 (discussed in this paper) demonstrated that the presented model still needs its theoretical aspects refining.

Despite the presented model was implemented according to the collective work needs elicited in cycles 1 and 2 (GAVA, 2009), it is observed that in cycle 3 (functional prototype use) users were not always able to understand what were their actual roles in the system, and could not stop using alternative means, such as parallel records.

Therefore, this research will continue during the implementation of cycle 3, aiming to bridge the gaps observed during the application of the model presented during cycles 1 and 2.

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